SOIL-MAT ENGINEERS & CONSULTANTS LTD.

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PROJECT NO.: SM 072893-G June 28, 2008

Philips Engineering Ltd.
3215 South Service Road
P.O. Box 220
Burlington, Ontario
L7R 3Y2

Attention: Mr. Scott Hamilton, B.A.Sc., P. Eng.

GEOTECHNICAL INVESTIGATION
PLAINS ROAD WEST STORM SEWER OUTFALL RELOCATION AT HIGH LEVEL BRIDGE
BURLINGTON, ONTARIO
CITY OF BURLINGTON FILE NO.: 570.02-366

Dear Mr. Hamilton,

Further to your authorisation we have completed the fieldwork and laboratory testing, and report preparation, in connection with the above noted project. Our comments and recommendations, based on our findings at the four borehole locations, are presented in the following paragraphs.

1. INTRODUCTION

We understand that the project will consist of the replacement of the existing storm sewer pipeline, along a portion of Plains Road West in Burlington, Ontario. This pipeline and manhole structures has experienced significant collapse/movements primarily due to erosion of the primarily granular supporting soils. The storm sewer outfall reconstruction project is associated with the sewer system servicing Spring Gardens Road, Botanical Drive, Plains Road West, and the future connection of Grandview Avenue, Plainsview Avenue and Brookview Avenue. The current reconstruction/replacement proposal consists of an 18-metre deep drop structure and an outlet pipeline leading to the base of the slope and Grindstone Creek.

This report is based on the above summarised project description, and on the assumption that the design and construction will be performed in accordance with applicable codes and standards. Any significant deviations from the proposed project design may void the recommendations given in this report. If significant changes are made to the proposed design, then this office must be consulted to review the new design with respect to the results of this investigation. The information contained in this report does not reflect upon the environmental aspects of the site and therefore have not been addressed in this document.

2. PROCEDURE

A total of four [4] sampled boreholes were advanced at the locations as access permitted and illustrated on the enclosed Drawing No. 1, Plan Showing Borehole. The borings were advanced using hollow stem continuous flight auger equipment under the supervision of SOIL-MAT ENGINEERS to depths of between about 0.75 and 27.7 metres below ground surface. Borehole Nos. 1, 2 and 3 were advanced on January 16, 2008 and Borehole No. 4 was advanced on May 29 and 30, 2008.

Representative samples of the subsoils were recovered from the borings at selected depth intervals using split barrel sampling equipment driven in accordance with the requirements of the ASTM test specification D1586, Standard Penetration Resistance Testing. After undergoing a general field examination, the soil samples were preserved and transported to the Soil-Mat laboratory for visual, tactile, and olfactory classifications. Routine moisture content tests were performed on all soil samples.

All surveying associated with locating the boreholes in the field and determining their ground surface elevations was carried out by representatives of Soil-Mat Engineers. The borehole locations were referenced to UTM co-ordinates using a hand held GPS unit with an accuracy of +/- 3 metres. The ground surface elevations were referenced to two geodetic benchmarks acquired from Philips Engineering Ltd.: Benchmark No. 1 is described as the manhole just east of the Plains Road West bridge span, at Elevation 100.61 metres. Benchmark No. 2 is describe as the southwest corner of the concrete of the east abutment at Elevation 95.43 metres.

The results of the subsurface investigation are detailed in Borehole Log Nos. 1 to 4, inclusive, which can be found following the text of this report. It is noted that the boundaries of soil types indicated on the borehole logs are inferred from non-continuous soil sampling and observations made during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and therefore should not be construed as the exact planes of geological change.

3. SITE DESCRIPTION AND SUBSURFACE CONDITIONS

The subject site is located on the south side of Plains Road West in Burlington, Ontario at the high level bridge structure over the Grindstone Creek. The property grade slopes to the west at an overall slope of about 3 Horizontal to 1 Vertical, with some steeper profile sections. The project area is currently primarily covered with high grasses, scrub vegetation and some mature trees. There were a number of ‘worn’ pathways found along the proposed sewer alignment.

The subsurface conditions encountered at the borehole locations are summarised as follows:

3.1 Borehole 1 [Advanced at top of slope near proposed Manhole No. 2]

A compact brown sand was proven to underlie the 100 millimetre veneer of topsoil material. The sand was found to contain traces of, to some, gravel. This sand was proven to a depth of approximately 3.7 metres. A reddish brown sandy silt, with significant clayey silt seams was found to underlie the sand. The sandy silt was found to contain a trace of fine gravel and to be in a loose to compact state, while the clayey silt seams were found to be stiff to very stiff in consistency. A sand and fine gravel was proven at a depth of about 9.0 metres below grade to underlie the sandy silt. The brown sand and fine gravel layer was found to be in a very dense state. A brown sand, fine to medium in gradation, was encountered beneath the sand and fine gravel. This sand was found to contain a trace of, to some, fine to medium gravel and was in a dense state. Although not encountered in this boring, boulders and naturally 'cemented' seams/layers are typically found in this deposit and should be expected by the contractor during excavation operations. A silty clay was found to underlie the sand at a depth of about 15.0 metres below grade. The silty clay was found to contain a trace of, to some, sand and gravel. Queenston Shale bedrock was encountered at a depth of about 26.5 metres below grade. It was noted to be generally reddish brown in colour, highly weathered in the upper level and to have occasional more resistant grey layers. The Queenston Shale bedrock was proven to termination of the boring at a depth of 27.5 metres below grade.

3.2 Borehole 2 and 4 [Advanced at proposed Outfall Headwall Structure]

A 100 millimetre veneer of topsoil was found to overlie a very loose to loose sand/silty sand in Borehole No. 2. A thin veneer of silty sand fill contain concrete rubble was proven in the upper level of Borehole No. 4. A loose sand/silty sand was found to a depth of about 5.8 metres in Borehole No. 4. The granular deposits were found to contain some black staining and organic inclusions/matter, which resulted in some moisture contents exceeding 80 percent and some silty clay in the lower levels. A very stiff silty clay was proven to underlie the sand/silty sand in Borehole No. 4. The silty clay was found to termination of this boring at a depth of 7.3 metres below the existing grade.

3.3 Borehole 3 [Advanced at existing Concrete Abutment]

Borehole No. 3 was attempted at the location shown on the attached Drawing No. 1, but due to large pieces of concrete debris refusal resulted at shallow depths. There were numerous attempts in the general area to advance this borehole, with all attempts resulting in the same outcome. The overlying soil was found to consist of a compact silty clay fill.

3.4 Groundwater Observations

Free groundwater was observed in the Borehole No. 2 at a depth of 4.1 metres upon completion, while the remaining borings were found to be 'dry' upon completion. The groundwater level in the 'lower' borings must be expected to be slightly 'higher' than that of the existing creek. Although not encountered in the 'upper' borehole, perched groundwater must be expected in more permeable granular deposits overlying the low permeability cohesive silty clay [aquitard].

4. DISCUSSIONS

We understand that the proposed 900 millimetre diameter concrete storm sewer pipe will be installed using open trench and backfill techniques, between the existing alignment [commencing at the proposed Stormceptor] and the 'drop-structure' [proposed Manhole No. 2]. The storm sewer will be advanced westerly from the 'drop-structure' to 'daylight' on the slope using 'jack and bore' tunnelling methods. The 'jack and bore' tunnel alignment should be located as low as possible to increase the thickness of the cohesive soils above the obvert of the tunnel and hence to reduce the possibility of the tunnel roof from caving into the excavation.

A naturalised meandering channel, within the existing floodplain area, will be constructed between the proposed concrete outfall headwall and Grindstone Creek.

The sides of excavations through the 'granular' soils should remained stable, for the short construction period, at 45 degrees to the horizontal to the anticipated depths of construction between the proposed Stormceptor and the 'drop-structure'. We note that all excavations must comply with the current Occupational Health and Safety Act and Regulations for Construction Projects. Excavation slopes steeper than those required in the Safety Act must be supported or a trench box must be provided, and a senior geotechnical engineer from this office should observe the work.

The majority of the excavated material will consist of the native sand and sandy silt material. These excavated 'granular' materials are considered to be suitable for use as storm sewer trench backfill provided the moisture content can be controlled within 2 or 3 per cent of the standard Proctor optimum value. Some moisture content conditioning of the excavated materials will be required, depending upon the weather conditions experienced at the time of construction, to achieve good compaction densities and minimise long-term settlements. At present, the upper 'granular' soils are considered to be generally near their optimum moisture contents. The base of excavations in the competent granular soils should remain firm and stable. It is expected that standard pipe bedding, as typically specified by the City of Burlington will suffice for any service

pipes. The bedding material should be well compacted, with special attention paid to compaction under the pipe haunches.

In the event that the 'jack and bore' operation is commenced at Manhole No. 2 the entry [starting] pit will need to be excavated to a depth of up to about 18 metres below the upper grade level. The starting pit will need to be about 4 metres by 10 metres in plan to allow for the access of workers and equipment. This excavation will need to be undertaken within the confines of a braced shoring scheme, such as a soldier pile and wooden timber lagging support system. The 'H-section soldier piles may be placed in holes advanced using conventional augering techniques to found in the underlying silty clay. Following placement of the soldier pile, and base concrete below the invert level of the excavation required, the remainder of the hole should be backfilled with a low-strength grout. To minimise settlements and stress relaxation around the supported excavation, we would recommend that any voids created behind the wooden timber lagging boards be filled with a well-graded 'packed' granular material and hardwood wedges should be driven between the wooden timber lagging boards and the piles as the excavation proceeds. We would further recommend that 'gaps' be filled with a geotextile product at strategic locations allow for drainage. Lateral earth pressures on shoring system can be estimated on the basis of a soil unit weight, γ = 21 kN/m^3, and a coefficient of active lateral earth pressure of 0.35. Any additional pressures due to surcharge loading must be included in the design. The braced shoring system must be designed [soldier pile spacing, size of wooden timber lagging boards, etc.] by an experienced structural engineer. The support system at the rear of the excavation must be designed to resist the jacking forces generated to advance the jack and bore tunnelling operations.

The jacking forces will have to be resisted by the earth pressure against the rear of the starter pit. The passive coefficient of earth pressure of 2 may be used in calculating the passive resistance of the wall. Higher values are available but require significant strains to develop. Additional walers/struts may be required at the rear of the starter pit to provide the requisite supplemental support. Close supervision is essential to ensure that the boring machine is not advanced ahead of the carrier pipe, to minimise stress relaxation and possibility of significant loss of ground [and water]. Once started, the 'jack and bore' operation should be continued until completed. Records should be maintained of the volume of soil removed during the 'jack and bore' operation to allow for comparison to theoretical volumes.

Following installation of Manhole No. 2 and the associated storm sewer pipe, the starter pit may be backfilled using the previously excavated material. We would recommend that imported granular material be provided and compacted to 100 per cent of its standard Proctor density within 0.6 metres of the manhole to mitigate settlement problems. Alternatively, the 'lower' portion of the starter pit could be backfilled with a

pre-mixed 'low-strength' cementitious product [0.5 MPa] and then to grade with the previously excavated materials.

Alternatively, the 'jack and bore' operation could start at the western limit of the underground works, which would minimise the size of excavation [receiving pit] at the 'drop-structure' [Manhole No. 2]. The excavation at the 'drop-structure' could be advanced with a large diameter auger machine using a steel liner to support the surrounding soils and limit 'cave' and soil disturbance/relaxation. The steel liner could be 'cut' to receive the concrete pipe. Again, the 'lower' portion of the receiving pit could be backfilled with a pre-mixed 'low-strength' cementitious product [0.5 MPa] to the upper invert level and then to grade with the previously excavated materials, although backfilling with the cementitious material would be preferred since compaction within the confined space between the steel liner and the concrete drop structure would be practically impossible.

The soil conditions encountered at the proposed concrete outfall headwall location are not favourable for support on conventional spread footings or for support of the concrete sewer pipe and the associated bedding and cover materials without experiencing significant settlements/movements. Therefore, we would recommend that the concrete outfall headwall structure and the westerly portion of the storm sewer pipe alignment be supported on helical piers advanced into the underlying native silty clay. Such piers could be designed to support a net allowable load of 180kN. The depth and length of helical piers would be a function of the type/strength of the supporting soils encountered, at the installation location, as confirmed by the results of the torque measurements made during installation. Negative skin friction on the slender pier shafts would be practically negligible. Helical piers may be used to resist the jacking forces if the 'jack and bore' operations commence at the western limit of the underground works.

It is imperative that a soils engineer be retained from this office to provide geotechnical engineering services during the excavation and foundation construction phases of the project. This is to observe compliance with the design concepts and recommendations of this report and to allow changes to be made in the event that subsurface conditions differ from the conditions identified at the Borehole locations.

5. GENERAL COMMENTS

The comments provided in this document are intended only for the guidance of the design team. The subsoil descriptions and borehole information are intended to describe conditions at the borehole locations. Contractors tendering or undertaking this project should carry out due diligence in order to verify the results of this investigation and to determine how the subsurface conditions will effect their operations.

We trust that this geotechnical report is sufficient for your present requirements. Should you require any additional information or clarification as to the contents of this document, then please do not hesitate to contact the undersigned.

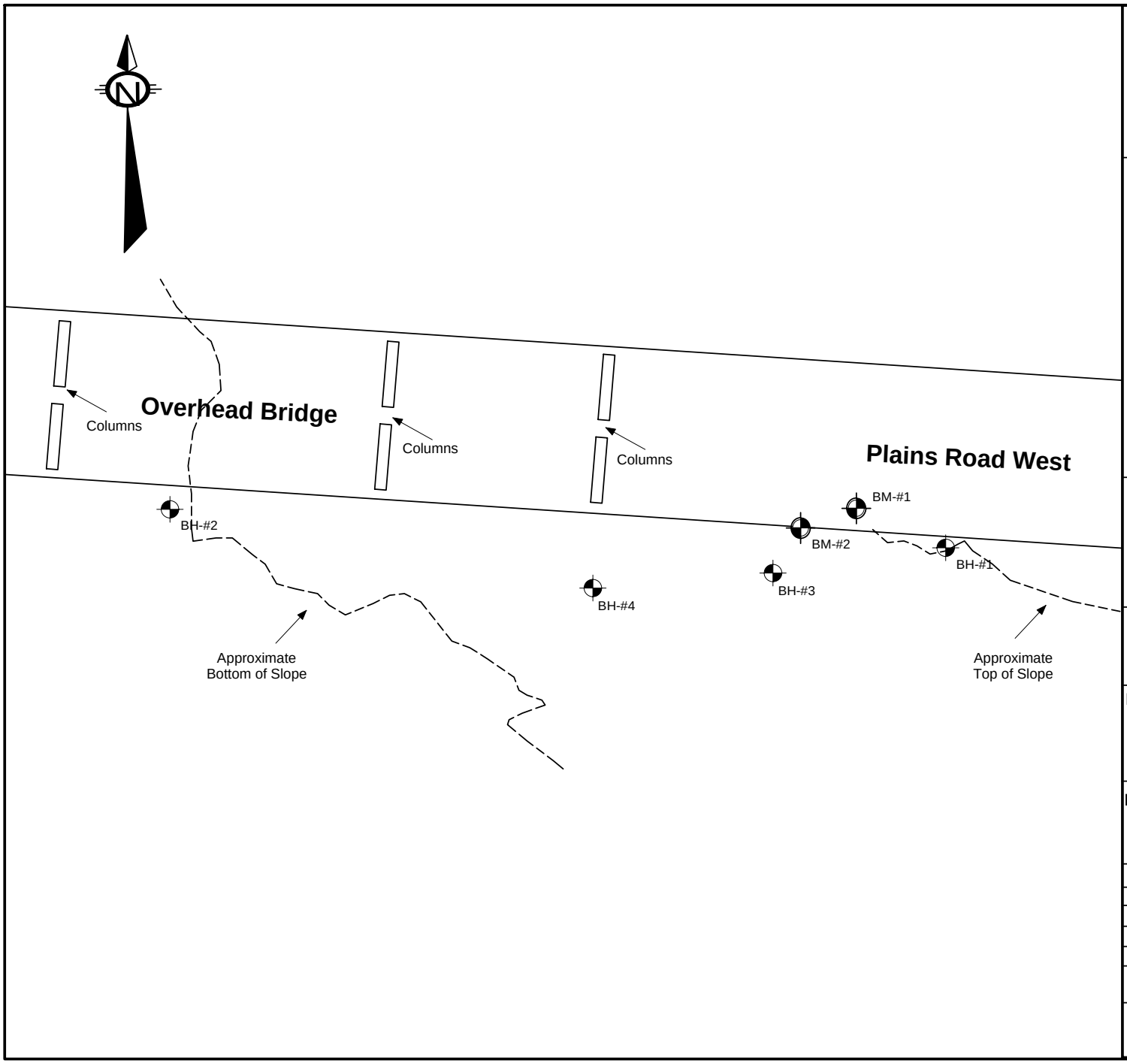
Yours very truly,
SOIL-MAT ENGINEERS & CONSULTANTS LTD.

John Monkman, P. Eng.
Project Engineer

Danny Schebesch, M.E.Sc., P. Eng.
Review Engineer

Enclosures: Drawing No. 1, Plan Showing Borehole Locations
Borehole Log Nos. 1 to 4, inclusive

Distribution: Philips Engineering Ltd. [3]



LEGEND

BH-# Borehole

Benchmark

NOTES:

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. report number SM 072893-G
2. Soil samples will be discarded after 3 months unless directed otherwise by client.
3. Topsoil depths may vary across site and from depths at borehole locations.
4. Borehole locations are approximate.
5. BM-#1 Elevation 100.61 metres. BM-#2 Elevation 95.43 metres.

Soil-Mat
Engineers & Consultants Ltd.

CLIENT

Philips Engineering

PROJECT TITLE

Geotechnical Investigation
Storm Sewer Outfall Relocation
Burlington, Ontario

DRAWING TITLE

Borehole Location Plan

PROJECT No.	SM 072893-G
SCALE	N.T.S.
DATE	June 2008
CHECKED	JM
DRAWN	RM
FILENAME	072893 Borehole Location Plan.kcw

DRAWING No. 1

Project No: SM 072893-G

Project: Storm Sewer Outfall Relocation

Location: Plains Road West, Burlington

Client: Philips Engineering Ltd.

Log of Borehole No. 1

Borehole Location: See Dwg. No. 1

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Project Manager: John Monkman, P.Eng.

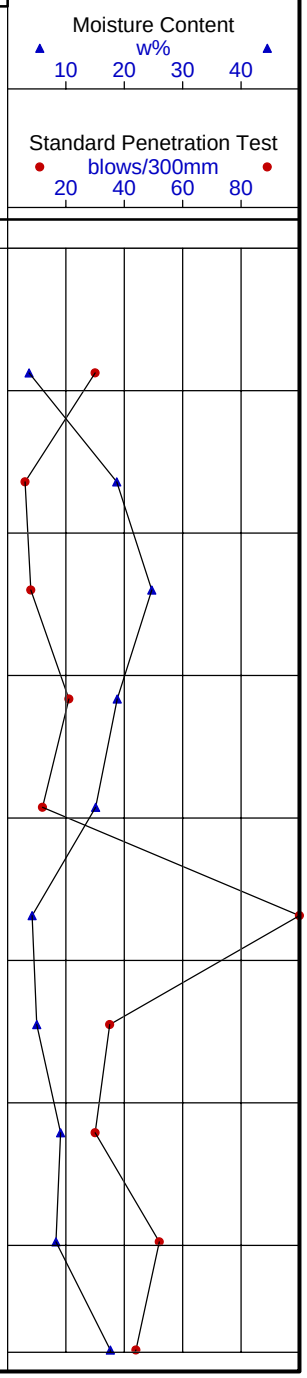
Soil-Mat

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Symbol	Description	Well Data
0	0	100.65		Ground Surface	
0–2				**Topsoil** Approximately 100 millimetres	
2–12	0–2			**Sand** Brown, medium grained, trace to some gravel, moist, compact	
12–20	4–6	96.95		**Sandy Silt/Clayey Silt** Reddish brown,trace fine gravel, moist, loose to compact	
20–22	6	94.25		Brown Sandy Seam	
22–30		93.65			
30–32		91.65		**Sand and Fine Gravel** Brown and some grey, moist, very dense	
32–50	10–14	90.65		**Sand** Brown, fine to medium in gradation, trace to some fine to medium gravel, faint layering, moist, dense	
50		85.65			

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	5,12,18	30			
SS	2	4,3,3	6			
SS	3	2,3,5	8			
SS	4	5,8,13	21			
SS	5	3,4,8	12			
		50/4"				
SS	7	8,17,18	35			
SS	8	9,16,14	30			
SS	9	9,26,26	52			
SS	10	8,18,26	44			



Drill Method: Hollow Stem Auge

Drill Date: January 16, 2008

Hole Size: 200 millimetres

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Sheet: 1 of 2

Project No: SM 072893-G

Project: Storm Sewer Outfall Relocation

Location: Plains Road West, Burlington

Client: Philips Engineering Ltd.

Log of Borehole No. 1

Borehole Location: See Dwg. No. 1

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Project Manager: John Monkman, P.Eng.

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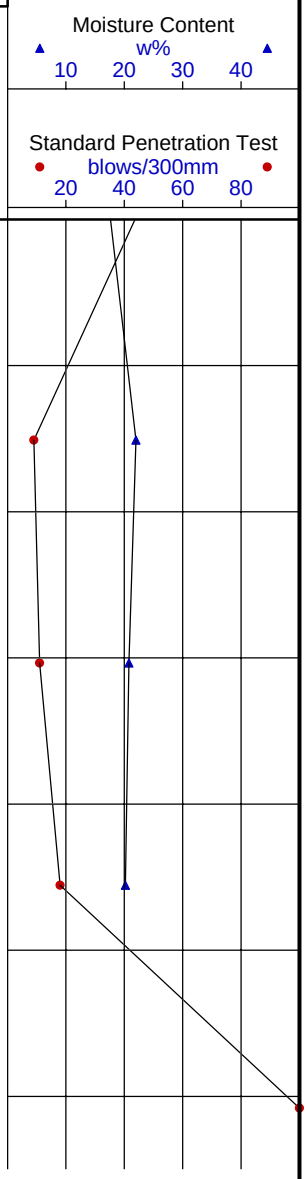
SUBSURFACE PROFILE

Depth	Elevation [m]	Symbol	Description	Well Data
52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92	18, 20, 22, 24, 26, 28		***Silty Clay*** Grey, trace of to some sand and fine to medium gravel in lower levels, moist, hard to stiff	
	74.15		***Queenston Shale*** Reddish brown, weathered, occasional more resistant grey layers becoming sounder with depth, hard	
	73.15		End of Borehole	

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	11	1,4,5	9			
SS	12	2,4,7	11			
SS	13	0,6,12	18			
		50/2"				



NOTES:

1. Borehole advanced using hollow stem continuous flight auger equipment on January 16, 2008 to termination at a depth of 27.5 metres.
2. Borehole dry on completion and backfilled as per Ontario Regulation 903.
3. Soil samples will be discarded after three months unless otherwise directed by our client.

Drill Method: Hollow Stem Auge

Drill Date: January 16, 2008

Hole Size: 200 millimetres

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Sheet: 2 of 2

Project No: SM 072893-G

Project: Storm Sewer Outfall Relocation

Location: Plains Road West, Burlington

Client: Philips Engineering Ltd.

Log of Borehole No. 2

Borehole Location: See Dwg. No.1

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Project Manager: John Monkman, P.Eng.

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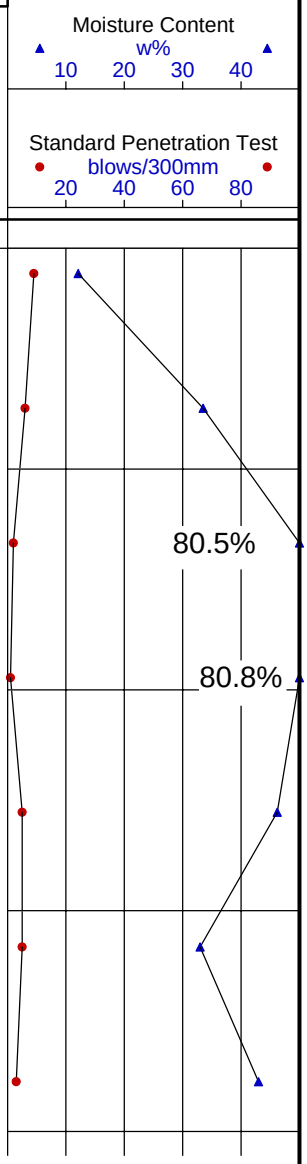
SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Description
0	0	75.24	Ground Surface
			Topsoil Approximately 100 millimetres
		74.24	**Sand/Silty Sand** Brown to brownish red with grey and black, with silty clay and gravel, moist, stiff/loose
	2		**Sandy Silt/Silty Sand** Brown to reddish brown, some black staining, some gravel in upper levels, trace to some organics, some clay in lower levels, wet, loose to very loose
	4		
	6		
	8	67.44	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,4,5	9			
SS	2	1,3,3	6			
SS	3	1,1,1	2			
SS	4	1,1,0	1			
SS	5	2,2,3	5			
SS	6	3,2,3	5			
SS	7	2,1,2	3			



NOTES:

1. Borehole advanced using hollow stem continuous flight auger equipment on January 16, 2008 to termination at a depth of 7.8 metres.
2. On completion of drilling water groundwater was observed at a depth of, 4.1 metres and borehole was backfilled as per Ontario Regulation 903.
3. Soil samples will be discarded after three months unless otherwise directed by our client.

Drill Method: Hollow Stem Auge

Drill Date: January 16, 2008

Hole Size: 175 millimetres

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Sheet: 1 of 1

Project No: SM 072893-G

Project: Storm Sewer Outfall Relocation

Location: Plains Road West, Burlington

Client: Philips Engineering

Log of Borehole No. 3

Borehole Location: See Dwg. No.1

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Project Manager: John Monkman, P.Eng.

Soil-Mat

SUBSURFACE PROFILE					SAMPLE							
Depth (ft / m)	Elevation [m]	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)	Moisture Content w% (10 20 30 40) / Standard Penetration Test blows/300mm (20 40 60 80)
	92.56		Ground Surface									
0			**Silty Clay Fill** With concrete rubble and debris									
2	91.81		End of Borehole									
4			NOTES: 1. Borehole advanced using hollow stem continuous flight auger equipment on January 17, 2008 to auger refusal at a depth of 0.75 metres. 2. Borehole was attempted to be advanced at numerous locations in the area, however, concrete debris caused refusal.									
6												
8												
10												
12												
14												
16												
18												
20												
22												
24												
26												
28												
30												
32												

Drill Method: Hollow Stem Auge

Drill Date: January 17, 2008

Hole Size: 175 millimetres

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Sheet: 1 of 1

Project No: SM 072893-G

Project: Storm Sewer Outfall Relocation

Location: Plains Road West, Burlington

Client: Philips Engineering Ltd.

Log of Borehole No. 4

Borehole Location: See Dwg. No.1

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Project Manager: John Monkman, P.Eng.

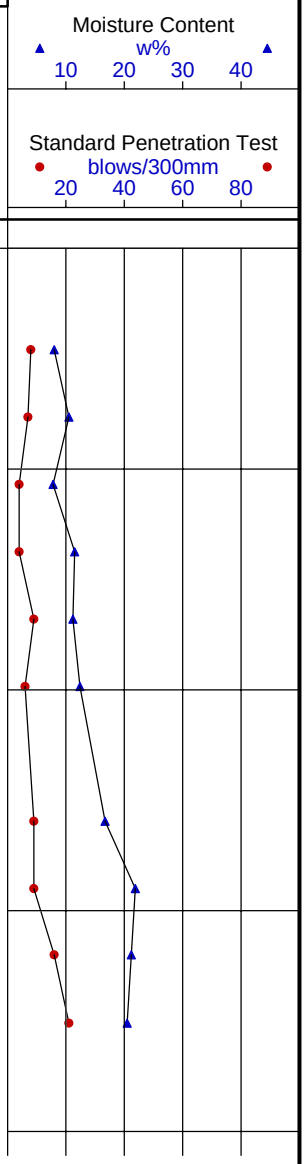
Soil-Mat

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Symbol	Description	Well Data
0	0	84.58		Ground Surface	
0–18.7	0–5.7			***Sand/Silty Sand Fill*** Brown, medium in gradation, some cobbles and concrete debris near surface, trace orgaincs and rootlets in upper levels, trace silty clay in lower levels, moist, loose	
18.7–24.4	5.7–7.4	78.78		***Silty Clay*** Grey, black staining in upper levels, some mottling, moist, very stiff	
24.4	7.4	77.28		End of Borehole	

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	3,4,4	8			
SS	2	4,3,4,1	7			
SS	3	2,2,2,3	4			
SS	4	3,2,2,3	4			
SS	5	3,4,5,5	9			
SS	6	4,3,3,4	6			
SS	7	9,4,5,6	9			
SS	8	8,4,5,6	9			
SS	9	4,7,9,6	16			
SS	10	6,7,14,15	21			



NOTES:

1. Borehole advanced using hollow stem continuous flight auger equipment on May 29 to 30, 2008 to termination at a depth of 7.3 metres.
2. Borehole was dry on completion and backfilled as per Ontario Regulation 903.
3. Soil samples will be discarded after three months unless otherwise directed by our client.

Drill Method: Hollow Stem Auge

Drill Date: May 29-30, 2008

Hole Size: 175 millimetres

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Sheet: 1 of 1